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Evaluating a Swiss German Sign Language Avatar among the Deaf Community

Sarah Ebling
Institute of Computational Linguistics
University of Zurich
8050 Zurich, Switzerland
ebling@cl.uzh.ch

ABSTRACT

This paper reports on an evaluation of an avatar for Swiss German Sign Language (*Deutschschweizerische Gebärdensprache*, DSGS) by native signers of this language. The avatar is the final output of a machine translation system which is being built to translate in real time German announcements of the Swiss Federal Railways (*Schweizerische Bundesbahnen*, SBB) into DSGS. An existing software, JASigning, is used to automatically generate the avatar animations. The evaluation data is from a focus group with seven Deaf signers who provided feedback on how to improve the DSGS avatar. They identified several aspects that had to be modified: Among them were the color of the avatar's clothing and the background, the direction of the avatar's default eyegaze, the speed of fingerspelling and mouthings, the temporal coordination of the manual and non-manual components of a sign, and the handling of lists of signs. These aspects are not just relevant for train announcements in DSGS, but for data of other kinds and other sign languages as well.

Categories and Subject Descriptors

I.2.7 [**Artificial Intelligence**]: Natural Language Processing—*Language generation*; K.4.2 [**Computers and Society**]: Social Issues—*Assistive technologies for persons with disabilities*

General Terms

Human Factors, Languages

1. INTRODUCTION

Sign language avatars are virtual signers that provide access to information for Deaf[1] individuals. It is clear that sign language avatars cannot and should not replace human sign language interpreters, although this is a fear often expressed by Deaf signers. Instead, the aim should be for both forms of signing to co-exist and be used for different purposes: Interpreters are needed where sign language rendering has to be as accurate as can be (e.g., at a doctor's appointment) and where the human component plays an important role. Sign language avatars are suitable for providing an anonymized representation of a signer. Automatically animated sign language avatars, in addition, are able to render dynamic content, e.g., display the sign language output of a machine translation system or present the contents of a sign language wiki [4].

To date, few studies have evaluated the acceptance and comprehensibility of sign language avatars among the Deaf community. An exception is [14]: The authors presented native signers of German Sign Language with avatars signing content in different sign languages. This paper reports on an evaluation of an avatar in one sign language by native signers of the same language, which corresponds to what we believe to be a crucial prerequisite for a successful evaluation. We carried out a focus group study with seven Deaf signers. Our aim was to obtain feedback on how to improve an avatar signing train announcements in Swiss German Sign Language.

The remainder of this paper is structured as follows: Section 2 discusses the above-mentioned evaluation study [14] in more detail. Section 3 introduces the project for which the DSGS avatar is being used. Section 4 describes the method of our evaluation and the setting. Section 5 presents the results of the study. Section 6 reports the improvements which have been implemented following the evaluation as well as those that still need to be tackled. In Section 7, an overview of the contribution of this work is given along with an outlook on future research questions.

2. RELATED WORK

[14] carried out two focus groups and an online survey to establish the Deaf user perspective on sign language avatars. As part of the focus groups, a total of eight native signers of German Sign Language were presented with six avatars signing content in different sign languages (American Sign Language, British Sign Language, Finnish Sign Language,

[1]It is a widely recognized convention to use the upper-cased word 'Deaf' for describing members of the linguistic community of sign language users and, in contrast, to use the lowercased word 'deaf' when describing the audiological state of a hearing loss [17].

German Sign Language, International Sign). Most of the avatars had been animated automatically. The participants were asked to discuss the strengths and weaknesses and vote on certain aspects of the avatars. The participants of the online survey (N=317) evaluated the same avatars with respect to the following criteria: comprehensibility, facial expression, naturalness, charisma, movements, mouthing, appearance, hand shapes, and clothing.

The Deaf participants found the majority of the avatars to be rather stiff and suggested including smoother and more relaxed movements of the upper body. They also found most of the avatars somewhat unnatural due to their lack of non-manual expression, which included the absence of mouthings and of variation in the movement of eyebrows, eyelids, and eyes. Moreover, the avatars' permanent eye contact with the viewer was found to be obtrusive. The participants also expressed their wish to see more movement of the cheeks, lips, teeth, and tongue, but at the same time cautioned against exaggerating these movements. Another point of criticism was the mismatch between the duration of manual components of a sign and the corresponding mouthings.

Like [14], we carried out a focus group study. It is clear that focus groups by themselves do not constitute comprehensive evaluation studies. However, given the early stage of our project we deemed them an appropriate method to obtain preliminary feedback on how to improve an avatar signing train announcements in Swiss German Sign Language from members of the Deaf community. The details of our focus group setting are given in Section 4. In what follows, we describe our project as part of which we are using a sign language avatar.

3. MACHINE TRANSLATION OF GERMAN TRAIN ANNOUNCEMENTS INTO SWISS GERMAN SIGN LANGUAGE

Deaf people today still face substantial barriers when using public means of transportation. Despite legal obligations in Switzerland to ensure accessibility for disabled people, much remains to be done in this area. For example, at railway stations, a considerable amount of information for passengers is conveyed via loudspeaker only and is not displayed in written form on the panels above the tracks. This makes it difficult for Deaf persons to know when a train is delayed or cancelled. A Deaf individual also has no access to announcements made by the loudspeakers on the trains.

A system has been built that converts French train announcements into French Sign Language (*Langue des Signes Française*, LSF) avatar animations and displays them on a monitor in a train station [20].[2] The system relies on parallel data consisting of written French announcements on the source side and LSF avatar animations on the target side, both as templates with slots, where slots can be, e.g., the names of train stations, types of trains, or reasons for delays. At runtime, the system identifies the template underlying the input segment and searches for the corresponding LSF avatar animation template. Subsequently, it fills the slots on the target side with the help of further written French–LSF avatar animation correspondences. However, simple concatenation is not enough: A coarticulation model is applied to ensure smooth transitions between surrounding and embedded animations. [20] performed a qualitative evaluation of the system and found that most users were satisfied with it. The users gave suggestions on how to further improve the system, e.g., through a more human-like appearance of the avatar. In addition, one participant proposed to make the avatar animations available not only on a monitor but also on a mobile phone.

We are building a system that automatically translates German train announcements of the Swiss Federal Railways (*Schweizerische Bundesbahnen*, SBB) into Swiss German Sign Language (*Deutschschweizerische Gebärdensprache*, DSGS). Our project team consists of two hearing and two Deaf researchers. DSGS is the sign language of the German-speaking area in Switzerland. It has approximately 6000 users [15] distributed across five dialects (Basel, Bern, Lucerne, St Gallen, Zurich). In our project, we focus on the Zurich dialect. To what extent DSGS is similar to German Sign Language is the subject of an ongoing study.

The final output of our system is an avatar that signs the train announcements in real time on a mobile phone. The corresponding German text is shown as a subtitle beneath the avatar. Announcements remain available for a certain time so that they can be replayed. Hence, the target group of the application are not only Deaf and hard of hearing persons but also hearing persons looking for a replay functionality for train announcements.

Our approach differs from the work of [20] in that we do not work with templates nor pre-built avatar animations during the actual translation step. Given the standardized nature of train announcements, the approach of [20] is the most suitable for this type of data. However, our core research interest is in sign language machine translation, and our goal is to build a translation system that may later be extended to other domains with more lexical and syntactic variation. For the system at hand, we expect the output to be of good quality, due precisely to the standardized nature of our data. Note that this is not representative of the overall performance of sign language machine translation systems.

The input to the system are written announcements in electronic form, such as shown in Example 1. We deal with messages conveyed by loudspeakers at train stations, not in trains.[3]

(1) *Ausfallmeldung zum RegioExpress nach Olten. Der RegioExpress nach Olten, Abfahrt um 6 Uhr 41, fällt aus. Grund dafür ist eine technische Störung an der Lok.*
'Notice of cancellation of the regional express to Olten: The RegioExpress to Olten, scheduled to leave at 6:41, has been cancelled due to a technical problem with the locomotive.'

[2]Other customer service systems have been developed: For example, the TESSA system [3] and its successor VANESSA [21] translate a post office clerk's (spoken or written) utterances into British Sign Language.

[3]The SBB use two different systems for this.

To obtain training, development, and test data for the machine translation system, we built a *parallel corpus* by manually translating a predefined number of German train announcements into DSGS. We received the German announcements from the SBB. To compile the parallel corpus, the hearing and Deaf members of our team

1. translated the written German train announcements into DSGS glosses;
2. signed the announcements in front of a camera on the basis of the gloss transcriptions;
3. notated the signs in the video recordings in the Hamburg Notation System for Sign Languages (HamNoSys) [19];
4. added information about non-manual features; and
5. generated the avatar sequences from the resulting code to make sure that the quality of the manual translations was satisfactory.[4]

In what follows, steps 1 (gloss transcription) and 4 (non-manual feature annotation) are discussed in more detail.

The team developed several conventions for glossing to ensure consistency. For example, we defined the following sign string format for time specifications: <STUNDEN> UHR <MINUTEN> ('<HOUR NUMBER> CLOCK <MINUTE NUMBER>'). For train names, we used two different formats: If a commonly used abbreviation for a train name existed, we fingerspelled the letters of the abbreviation. This was the case, e.g., for *InterRegio* (IR) or *InterCity* (IC). In all other cases, we concatenated existing DSGS lexical signs; e.g., EURO ('EURO') and NACHT ('NIGHT') for *EuroNight*; STADT ('CITY'), NACHT ('NIGHT'), and LINIE ('LINE') for *CityNightLine*; or NACHT ('NIGHT') and VOGEL ('BIRD') for *Nightbird*.

We used lexical signs for widely known places such as Zurich, Basel, or Lucerne. For all other places (e.g., Sisikon, Wassen), we applied fingerspelling. Where several places co-occurred, we introduced a short pause after each: An example is the German announcement *Bus nach Wassen, Gurtnellen, Altdorf: Abfahrt auf dem Bahnhofplatz* ('Bus to Wassen, Gurtnellen, Altdorf: departure from the station square'), where we introduced a pause after the place names *Wassen*, *Gurtnellen*, and *Altdorf* in the corresponding DSGS translation.

3.1 HamNoSys Notation

The videotaped sign sentences were notated in the Hamburg Notation System for Sign Languages (HamNoSys) [19]. This step was necessary because the avatar software we use relies on HamNoSys input. HamNoSys consists of approximately 200 symbols. It takes explicit account of the following sublexical components: hand shape, hand position (with extended finger direction and palm orientation as subcomponents), location, and movement. Where possible, we used the notations available in the DSGS databank of [1]. For all other signs, we created new notations.

An XML representation for HamNoSys exists as the Signing Gesture Markup Language (SiGML) [8]. Figure 1 shows the HamNoSys notation of the sign LAUTSPRECHER ('LOUDSPEAKER') in DSGS along with the corresponding SiGML code for the manual part of the sign.[5] The sign is performed by opening and closing the dominant hand next to the ear.

3.2 Non-Manual Feature Annotation

As a last step in the process of translating the German train announcements into DSGS, information was added about non-manual features, i.e., about mouthings and mouth gestures, head and shoulder movements, eyebrow movements, eyegaze, etc. Research on many European sign languages has shown that mouthings are not only capable of distinguishing between manual homonyms but also, when stretched over multiple signs, have an important prosodic function [2]. The mouthings used in DSGS are derived from Standard German rather than one of the Swiss German dialects. Sometimes the German words from which they are derived are reduced to the part of the pronunciation that is visible on the lips [2]. For example, the mouthing for MÜNCHENBUCHSEE, a place name sign in DSGS, is /Münchenbusee/, i.e., the fricative [x] (second occurrence of /ch/) is eliminated.

Codes for mouthings are available in SiGML through the Speech Assessment Methods Phonetic Alphabet (SAMPA) [22], an ASCII version of the International Phonetic Alphabet (IPA). As an example, /Lautsprecher/ ('loudspeaker') is notated in SAMPA as `'laUt|,SprE|C@r|`. Since DSGS involves German mouthings, we used the SAMPA notations of the Bonn Machine-Readable Pronunciation Dictionary for German (BOMP) [18] containing 141,230 entries. Where necessary, we modified them. Missing notations were also added.

We also added non-oral non-manual features (eyebrows, eye gaze, eyelids, nose) as well as non-facial non-manual features (head, spine, shoulders). Mouth gestures, non-oral non-manual features, and non-facial non-manual features are available in HamNoSys through alphanumeric codes (e.g., `L04` for pursed lips, `RB` for raised eyebrows, or `NO` for head nod) [10].

To automatically generate the avatar animations, we use the Java Avatar Signing (JASigning) system [7, 6, 5, 9, 12, 13][6] developed during several international projects (ViSiCAST,[7] eSIGN,[8] and DictaSign[9]). The system is freely available for research purposes. The Anna avatar character available in this software is shown in Figure 2. The software takes SiGML code as input.

We were interested in evaluating the quality of the avatar

[4]Note that for the machine translation step, the sign language side of the corpus is represented with glosses and HamNoSys notations.

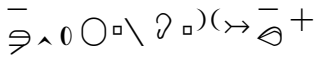
[5]Two SiGML variants exist: HNS SiGML and Gestural SiGML. Shown here is Gestural SiGML.

[6]`http://vh.cmp.uea.ac.uk/index.php/JASigning`

[7]`http://www.visicast.cmp.uea.ac.uk/`

[8]`http://www.visicast.cmp.uea.ac.uk/eSIGN/`

[9]`http://www.dictasign.eu/`



```
<sign_manual>
  <handconfig ceeopening="slack" handshape="ceeall" mainbend="bent"/>
  <handconfig extfidir="u"/>
  <handconfig palmor="l"/>
  <location_bodyarm contact="close" location="head" second_location="ear" second_side="right_beside"
  side="right_beside"/>
  <rpt_motion repetition="fromstart">
      <tgt_motion>
        <changeposture/>
        <handconfig handshape="pinchall" mainbend="bent"/>
      </tgt_motion>
  </rpt_motion>
</sign_manual>
```

Figure 1: HamNoSys notation and corresponding SiGML code for the manual part of the sign LAUTSPRECHER ('LOUDSPEAKER') in Swiss German Sign Language

Figure 2: JASigning avatar character Anna

ID	Age	Sex
1	22	F
2	39	M
3	42	M
4	49	F
5	51	F
6	58	M
7	69	M

Table 1: Demographic information about the participants of the study

animations generated from our notations at an early stage in the project, i.e., before developing the machine translation system and the mobile phone application. In what follows, we describe our evaluation method.

4. METHOD

[14] found focus groups to be "an excellent method to elicit criticism, constructive suggestions and opinions of Deaf participants". A focus group as a method of qualitative research is a "group interview ... based on topics that are supplied by the researcher who typically takes the role of a moderator" [16]. We evaluated the DSGS avatar signing train announcements with this method. Our goal was to receive preliminary feedback as to which aspects of the avatar could be improved.

We followed the recommendation of [14] to provide a sign-language-only setting, i.e., no hearing persons were allowed in the room in which the evaluation took place. A Deaf member of our project acted as moderator. We invited seven participants who were active members of the local Deaf community and were native signers of the language they evaluated (DSGS), which corresponds to what we believe to be a crucial prerequisite for a successful evaluation. The group consisted of four men and three women of ages 22 to 69 (cf. Table 4 for the complete age distribution).

The chairs were arranged in a semi-circle, without table to help provide a more casual and personal atmosphere as well as assure that all participants could see both the screen and each other. One of the participants had Usher syndrome, i.e., he is a DSGS user but is gradually becoming nearly blind. Since he currently finds it difficult to adjust to different lighting conditions and backgrounds, we placed one chair in front of a dark background and asked each participant waiting to make a statement to take a seat in this chair. Figure 3 shows the arrangement of seats. We filmed


Figure 3: Focus group study setting

the discussion with four cameras (of which two are visible in Figure 3).

Although the final output of our machine translation system is an avatar along with subtitles, we refrained from showing the subtitles to the focus group participants, as we wanted them to focus on the signing. Nine signed sentences were projected onto a screen (cf. Figure 3). The sentences had been chosen so as to reflect important characteristics of the sign language of our corpus, such as use of fingerspelling, rhetorical questions, indexical signs, or lists of signs. For every sentence, the moderator asked for the participants' individual suggestions for improvement. She replayed avatar sequences upon request.

5. RESULTS

The participants' first recommendation was to use a different color than red and light blue for the avatar's clothing and background. This was particularly emphasized by the participant with Usher syndrome. The participants also agreed that the avatar's eyegaze should be raised slightly so that it would be directed towards the viewer. They found the posture of the avatar and the display window (cf. Figure 2) appropriate. However, they felt the transition movements between some signs to be too abrupt. Moreover, they recommended that the hands return to a neutral position at the end of every signed announcement rather than to come to rest in the final posture of the announcement.

A further point of criticism concerned the temporal coordination of the manual and non-manual components: One of the sentences we showed contained an indexical (pointing) sign performed in a bottom corner of the signing space. The sign was accompanied by a movement of the head and the eyes towards the location of the indexical sign. The participants made clear that in order for the signing to appear natural in this case, the onset of the non-manual features (head and eye movement) had to precede the manual activity (indexical sign).

The participants recommended slightly speeding up the mouthings. Moreover, they observed that the avatar's teeth and tongue were hardly visible; they found this to be necessary, e.g., when forming the mouthing for the fingerspelled sign N. They also found the speed of the fingerspelling to be too high.[10]

A long discussion developed among the participants about how to deal with lists of place names. As stated in Section 3, where several place name signs appeared together, we introduced a short pause after each. The participants agreed that a pause was not enough to mark the boundaries of individual place name signs in a list, regardless of whether they were lexical or fingerspelled. They discussed the following as different possible strategies:

- preceding every place name sign with the sign ORT ('PLACE') as a contextualization marker;
- returning the hands to a neutral position after every place name sign; or
- performing a sign like THEMAWECHSEL ('CHANGE OF TOPIC') or WEGSCHIEBEN ('PUSH ASIDE') after every place name sign.

In the end, they opted for a combination of the first two strategies: performing the sign ORT once, then returning the hands to a neutral position after every place name sign. The participants also suggested using the contextualization marker ORT together with single occurrences of place name signs, even the widely known ones such as ZURICH, BASEL, or LUCERNE.

Our conventions for the DSGS announcements used similar contextualization markers for train names, e.g., ZUG INTERREGIO ('TRAIN INTERREGIO'), and time specifications, e.g., UHR 22 PUNKT 41 ('CLOCK 22 DOT 41'). However, the participants did not approve of the format used for time specifications, UHR <STUNDEN> PUNKT <MINUTEN> ('CLOCK <HOUR NUMBER> DOT <MINUTE NUMBER>') (cf. Section 3). They suggested using instead a phrasing more familiar to them without the 'DOT': <STUNDEN> UHR <MINUTEN> ('<HOUR NUMBER> CLOCK

[10]The use of fingerspelling is relatively recent in the DSGS community. As a result, DSGS users today have a varying ability in the production and comprehension of fingerspelled words.

<MINUTE NUMBER>') If this were used, they decided that prepending a contextualization marker like ZEIT ('TIME'), resulting in the sign sequence ZEIT <STUNDEN> UHR <MINUTEN> ('TIME <HOUR NUMBER> CLOCK <MINUTE NUMBER>'), was not necessary.

Regarding time specifications, the participants also criticized that a spatial offset between the location of the number of hours and the number of minutes was missing: They pointed out that in a temporal expression like *22:41*, the number of hours (*22*) should be signed in front of the body and the succeeding number of minutes (*41*) slightly to the right. The same convention was recommended to be used for train names involving numbers, e.g., *S6*, where *S* should be signed in front of the body and *6* slightly to the right.

The participants also found that the default transition time between specific combinations of signs was too long. This involved compound-like signs such as BAHN VERKEHR ('RAILROAD TRAFFIC'), ABFAHRT ORT ('PLACE OF DEPARTURE'), or FAMILIE WAGEN ('FAMILY WAGON'), but also cases in which DSGS uses two signs to refer to a single concept, like AUGE VORSICHT ('EYE CAUTION') for *Vorsicht* ('caution'), VERSPÄTUNG NACH ('DELAY AFTER') for *Verspätung* ('delay'), or SCHLIESSEN ZU ('CLOSE CLOSED') for *schliessen* ('close').

6. DISCUSSION

Following the feedback of the focus group participants we made several improvements to the DSGS avatar. For example, we changed the color of the avatar's clothing and background. As suggested by the participants, we used a dark color for both: teal (bluish green) for the background and black for the clothing.

We caused the hands to return to a neutral position at the end of every signed announcement. Moreover, we slightly sped up the mouthings and decreased the speed of fingerspelled signs. We introduced the contextualization marker ORT before place name signs and, in lists, additionally caused the hands to return to a neutral position after every place name sign. We changed the format of time specifications to <STUNDEN> UHR <MINUTEN> ('<HOUR NUMBER> CLOCK <MINUTE NUMBER>'). Along with this, we introduced a second set of HamNoSys notations for numbers between 0 and 60 whose location was slightly shifted to the right compared to the original set of notations. We then implemented a rule according to which instances of <STUNDEN> ('<HOUR NUMBER>') were drawn from the first set (resulting in number signs performed in front of the signer's body), whereas instances of <MINUTEN> ('<MINUTE NUMBER>') were drawn from the second set (yielding a signing location slightly to the right).

We also eliminated the temporal gap between compound-like signs such as BAHN VERKEHR ('RAILROAD TRAFFIC'), ABFAHRT ORT ('PLACE OF DEPARTURE'), or FAMILIE WAGEN ('FAMILY WAGON') by introducing additional (compounded) lexicon entries for these occurrences (i.e., BAHNVERKEHR, ABFAHRTSORT, FAMILIENWAGEN).

A few improvements remain to be implemented. For example, we are currently looking into ways of manipulating the temporal coordination of the manual and non-manual components of a sign so that, e.g., the onset of head and eye movements precede the manual activity of a sign. To date, JASigning only offers built-in functionality to manipulate (i.e., pre- or postsynchronize) the timing among different non-manuals.

7. CONCLUSION

This paper has reported on an evaluation of an avatar for Swiss German Sign Language (DSGS) among members of the Deaf community who use this language. The avatar is the final output of a machine translation system which is being built to translate German announcements of the Swiss Federal Railways into DSGS in real time. An existing software, JASigning, is used to automatically generate the avatar animations.

The evaluation data is from a focus group with seven Deaf signers. They identified several aspects that could be improved: Among these aspects were the color of the avatar's clothing and the background, the direction of the avatar's default eyegaze, the speed of fingerspelling and mouthings, the temporal coordination of the manual and non-manual components of a sign, and the handling of lists of signs. These aspects are not just relevant for train announcements in DSGS, but for data of other kinds and other sign languages as well.

While this paper has focused on the *acceptance* of the DSGS avatar, as our next step we plan to assess the *comprehensibility* of the DSGS train announcements among the Deaf community. [11] showed that asking participants directly about their level of comprehension is not advisable: "There appears to be a difference between a respondent's *perceived* understanding and her *actual* understanding of an animation." To test actual understanding, the authors suggested including a comprehension task in the evaluation. This is what we intend to do.

In the final stage of the project, we are going to conduct an online survey to assess the overall acceptance and comprehensibility of the DSGS avatar. Given the relatively small number of DSGS users, the sample size of this survey cannot be expected to be large. However, we hope for a sufficiently high response rate for the findings to be generalizable to the population of DSGS users.

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